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Accounting for Climate Change: Literature Review on Climate Disclosure and Environmental Risk Reporting

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ABSTRACT

Global climate change has become a major challenge affecting various sectors of life, including business and finance. Accounting plays a vital role in managing environmental risks and greenhouse gas (GHG) outflows, as well as their effect on corporate monetary articulation. By adopting carbon accounting and environmental accounting, companies can identify, measure, and report the environmental impacts of their activities, which in turn support climate change mitigation policies. Challenges in environmental reporting, such as varying standards across countries, hamper transparency and accountability. This article also highlights the importance of developing harmonized reporting standards to enhance public and investor confidence. Through literature analysis, this study provides insights into how companies can integrate sustainability practices into their business strategies, as well as the policy implications needed to support effective climate risk management. These findings are expected to be a reference for academics, practitioners, and policy makers in their efforts to achieve better sustainability and climate change mitigation.

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INTRODUCTION

In 2018, there were 315 cases of natural disasters worldwide, most of which were related to climate change (Fawzy et al., 2020). This phenomenon is caused by an increase in greenhouse gases (GHG) in the atmosphere due to human activities, such as deforestation, land conversion and industrial activities (Marrone et al., 2020). Global climate change is one of the greatest challenges facing humanity in modern times. The significant impacts of climate change on natural and human systems demand bold policy action. Many companies across countries and sectors are committed to addressing this issue through sustainable policies and measures (Kouloukoui et al., 2019). Climate change poses both risks and opportunities for businesses. Companies face financial risks related to regulatory changes and the physical impacts of climate change. Conversely, there are opportunities for businesses that can adapt to or mitigate these changes, such as developing sustainable products or increasing energy efficiency (He et al., 2022).

Developing mindfulness of the reality that accomplishing worldwide climate and supportability targets requires mainstability arrangement (Monasterolo, 2020). According to Sustainable Development Goals (SDGs) no. 13, global warming, caused by increasing CO2 concentrations and greenhouse gas (GHG) emissions, is a crucial issue (Carmela Gulluscio et.al., 2023) . SDGs is a global agreement document consisting of goals and 169 targets to achieve sustainable development, while facing challenges in the development process. Since 1979, until 2020 the UN has set its achievements to increase to 247 goals (Hidayat, 2022). International agreements have sought to raise awareness of the risks of climate change and the need to reduce greenhouse gas (GHG) emissions (Nieto, 2019). If GHG emissions continue at current rates, global warming is projected to reach 1.5 °C between 2030 and 2052 (Fawzy et al., 2020).

In the 2015 Paris Agreement, governments around the world recognized the urgency of limiting global warming to a maximum of 2°C above pre-industrial temperatures, or risk severe impacts on the many natural systems on which we depend (Dwyer & Unerman, 2020). On December 12, 2015, more than 160 countries, both developed and developing, agreed to an international agreement to address the problem of global warming, which is a crucial issue in triggering climate change (Mahardika, 2020). Then, in 2016, the United Nations launched the 2030 Agenda for Sustainable Development, rooted in 17 Sustainable Development Goals (SDGs), while the European Commission launched the European Union (EU) 2030 agenda, which requires the EU as a whole to reduce its emissions by 40% by 2030 (Monasterolo, 2020).

According to the Intergovernmental Panel on Climate Change (IPCC) 2014, since the 1950s, the atmosphere and oceans have warmed significantly. The amount of ice and snow has decreased, sea levels have risen, and greenhouse gas concentrations have continued to increase (Linnenluecke et al., 2015). In its 2018 overhaul, the Interval Boardn on Climate Change (IPCC) made clear the logical prove presently appears emphatically that worlwhide warming of more than 1.5°C of warming. There's an pressing require for noteworthy activity to decorbonize the economy to anticipate to anticipate encourage warming (Dwyer & Unerman, 2020). The scientific evidence shows that we need to respond to the threats posed by climate change across business, industry and society. And we need to adapt to the changes that will occur even if greenhouse gas emissions are stopped immediately (Linnenluecke et al., 2015).

Adaptation and mitigation are two strategies carried out to address climate change (Amran et al., 2016). Adaptation responses are costly to the impacts of climate change

(Opp et al., 2022). According to IPCC 2012, adaptation to climate change can be defined as "the process of adjusting to expected climate change and its impacts, in order to reduce damage or take advantage of opportunities". Adaptation actions include a variety of strategies, such as improving infrastructure to cope with extreme weather, better managing water resources, and developing climate-resilient agricultural practices (Linnenluecke et al., 2015). Accounting plays a role in climate mitigation pathways towards a low-carbon transition (Battiston, Monasterolo, et al., 2021). Carbon is a small part of total greenhouse gas (GHG) emissions (Saud et al., 2020). Relief is done to diminish adjustment fetched since on the off chance that nursery gas consentration trigger climate alter, the affect of climate changes adaption and moderations exercise can be carried out in different segmens of life, for illustration the fisheries, marine, rural, and other divisions (Lubis et al., 2023). Reducing greenhouse gas (GHG) emissions through sustainable ecosystem management is seen as a key element in the strategy to achieve this goal (Don et al., 2024). Climate change also has a significant impact on the business and financial sectors (Carmela Gulluscio et.al., 2023).

In this context, accounting plays an important role in resource management and mitigating the impacts of climate change (Idrawahyuni et al., 2020). Accounting has a vital role in ensuring transparency and accountability in climate finance reporting, which is an essential element in meeting international financial commitments to support developing countries in their efforts to mitigate and adapt to climate change (Weikmans & Roberts, 2019). The role of climate change accounting includes identifying and reporting financial risks related to environmental impacts, as well as disclosing greenhouse gas emissions through carbon accounting practices. Accounting also drives the development of new tools and practices to address complex climate-related issues, ensure accountability and transparency in financial reporting, and help organizations make more sustainable and responsible decisions regarding environmental impacts (Laine et al., 2017).

Accounting provides a framework and methodology for measuring environmental impacts, such as greenhouse gas emissions, resource consumption, and waste production (Linnenluecke et al., 2015). Environmental impact measurement is a crucial tool that enables companies to understand and manage their impact on the environment. It also contributes to global efforts to address the challenges of climate change and achieve sustainability (Marrone et al., 2020). Carbon accounting practices and greenhouse gas emissions disclosure serve to provide transparent information about the environmental impact of an organization's operations, as well as to meet accountability demands from stakeholders (Laine et al., 2017).

Accounting also reports on the financial impacts caused by the environment, called environmental management accounting. This includes the need to disclose information about the costs and benefits of sustainable practices, support better decision-making regarding resource distribution, and increase transparency and accountability to stakeholders (Omran & Yaaqbeh, 2023). Environmental accounting facilitates transparent reporting of climate impacts to stakeholders, including investors, regulators and the public. This transparency is essential to building trust and demonstrating corporate responsibility. The importance of meaningful environmental reporting, which can increase the credibility of the information provided (S. Schaltegger & Roger Burritt, 2017). Based on the description above, the main objective of this systematic literature

review is to develop theories and practices of climate change accounting, identify and analyze approaches, challenges, and best practices in environmental risk reporting.

METHODOLOGY

This study uses a literature review method. Data were collected through searching and analyzing journal articles, e-books related to accounting for climate change (Wulandari et al., 2023). The sort of information utilized in auxiliary information. The investigate was conducted from 2015 to 2024 by looking national and worldwide diaries recorded by google researcher, Sinta, and scopus through the perish/harzing application, using the keywords climate, climate change, accounting for climate change, disclosure, and environmental risk reporting (Dewi & Budianto, 2022). The research stage is carried out by 1) The inquire about of determined according to the objectives. 2) Relevant literature is collected from sources such as ebooks, articles, and journals. 3) The selection of literature focuses on quality and relevance. 4) The literature is arranged based on certain themes for a structured review. 5) Literature analysis is carried out critically. 6) Synthesis is carried out by identifying relationships and patterns in the literature (Lubis et al., 2023).

The relevant data analysis techniques for the study begin with source identification and Article selection. At this stage, the researcher conducts a systematic literature search using academic databases to find relevant articles on climate change, climate change accounting, disclosure, and environmental risk reporting. The second stage is data categorization, which is grouping articles into categories based on emerging themes, for example: climate change, climate change accounting, disclosure, and environmental risk reporting. The third stage is Quantitative Analysis (if relevant), where there is numerical data available, such as the amount of reported emissions or the effectiveness of mitigation strategies, statistical analysis can be applied to evaluate trends and relationships between variables. The next stage is thematic synthesis, which is summarizing and synthesizing findings from various articles to identify key themes, challenges, and best practices. This helps in building a comprehensive framework for environmental risk reporting. Then, quality evaluation, which is assessing the quality and credibility of the studies analyzed. This can be done by using evaluation tools such as checklists to determine the legitimacy and reability of the strategies utilized within the ponder.

RESULTS AND DISCUSSION

Accounting for Climate Change: Concepts and Approaches

Carbon Accounting and Environmental Accounting

Carbon accounting is characterized as a framework thai utilizes bookkeeping strategies and methods to gather, record and analyze data related to climate change. This system also calculates and reports carbon-related assets, liabilities, expenses, and revenues, in order to provide useful information in decision-making for internal management and external stakeholders. (He et al., 2022). Emisi CO2 memiliki dampak negatif terhadap lingkungan, terdapat peningkatan tekanan dari regulator, pelanggan, dan masyarakat untuk mengurangi total emisi CO2 (Cadez & Czerny, 2016). Accurate carbon accounting is crucial to support climate policies and incentives for mitigation actions, as well as to achieve the emission reduction targets set out in the United Nations Framework Convention on Climate Change (UNFCCC) (Brander et al., 2021). Carbon accounting is part of a more comprehensive environmental accounting, where both focus

on measuring and managing the environmental impacts of human activities. In addition, both also aim to create standards that can be applied in carbon trading and emission reduction (Wolf & Ghosh, 2020). Environmental accounting is a field of research that focuses on how companies measure, disclose, and manage the environmental impacts of their activities. It includes an analysis of how environmental performance can affect the overall performance of a company (Marrone et al., 2020).

Regulations and Standards

In the face of global challenges such as climate change, organizations are encouraged to increase transparency and accountability regarding their social and environmental impacts. This also aims to meet the information needs of various stakeholders and contribute to the achievement of the Sustainable Development Goals (SDGs). In addition, the increasing demand from investors for ESG aspects shows that sustainability is now seen as a necessity. This makes sustainability reporting a crucial tool for creating long-term value for society and the environment (Adams & Abhayawansa, 2022). Sustainability reporting is very important because it helps stakeholders in assessing the sustainability performance of the company and supports better decision-making regarding investments and policies. There are various standards used to prepare sustainability reports (Kasperzak et al., 2023).

1) Global Reporting Initiative (GRI) is an international standard that helps organizations understand and communicate their impact on issues such as human rights, corruption, and climate change. GRI is recognized as the leading standard for sustainability reporting and has a modular structure that makes it easy to update and adapt. It is said that GRI has reporting guidelines that are widely adopted by companies around the world to increase transparency and accountability in environmental and social reporting (Kouloukoui et al., 2019). By adopting GRI standards, companies can convey information in a transparent and comparable manner, enabling stakeholders to conduct comparative analysis of the company's sustainability performance (Luo & Tang, 2023). 2) Greenhouse Gas Protocol (GHG Protocol) is an international standard that aims to help organizations and companies measure and report greenhouse gas (GHG) emissions. This protocol was developed collaboratively by the World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI) to provide clear guidance on identifying, calculating and reporting GHG emissions, both for internal and external needs (Kasperzak et al., 2023). 3) Task Force on Climate-related Financial Disclosures (TCFD) is a framework designed to assist companies in disclosing information about the risks and dependencies arising from climate change (Dwyer & Unerman, 2020). The errand drive on climate-related budgetary divulgence (TCFD) Energizes companies to reveal climate chance systematically and consistently, thereby increasing accountability and transparency in financial markets (Monasterolo, 2020).

Environmental Risk Reporting

Climate risks can be divided into two main categories: physical risks, which relate to the direct impacts of climate change such as natural disasters, and transition risks, which arise from the shift to a low-carbon economy, including new policies and changes in markets (Monasterolo, 2020). The short-term impacts of climate-related risks can include increased operating costs due to regulatory changes or fluctuations in energy prices. Meanwhile, long-term impacts can include asset impairments due to reduced

demand for unsustainable products or losses caused by physical damage from extreme weather events. In addition, companies that do not manage these risks well can face issues in asset valuation, such as goodwill impairments and changes in the estimated useful life of assets (Dwyer & Unerman, 2020).

Overall, the Task Force on Climate-related Financial Disclosures (TCFD) is considered a significant and relevant framework in the context of sustainability reporting. The TCFD offers recommendations to help companies identify, measure, and disclose risks and opportunities related to climate change. These recommendations include disclosures on governance, strategy, risk management, and metrics and targets used to measure and manage climate-related risks (Chua et al., 2022). Details of the recommended disclosures for each of these areas are described in Figure 1.

Governance	Strategy	Risk Management	Metrics and Risks
a. Board oversight of climate-related risks and opportunities, b. Management's role in assessing and managing climate-related risks and opportunities.	a. Climate-related risks and opportunities in the long, medium and short term. b. Impact of climate-related risks and opportunities on business, strategy and financial planning. c. Resilience of the organization's strategy across climate-related scenarios.	a. The process for identifying and assessing climate-related risks, b. The process for managing climate-related risks, c. The way in which the process is integrated into overall risk management.	a. Metrics to assess climate-related risks and opportunities that are aligned with the risk management strategy and processes, b. Scope 1, 2, and 3 greenhouse gas (GHG) emissions and associated risks, c. Targets applied to manage climate-related risks and opportunities and performance against those targets

Figure 1: TCFD disclosure recommendations, taken and adapted from the TCFD (Committee & Safety, 2017)

Companies face a number of challenges in measuring and communicating climate-related risks, including the complexity and uncertainty in predicting the impacts of climate change (Kim et al., 2023). One of the challenges often faced is measuring carbon emissions accurately. This involves collecting data from multiple sources, which can be very complex and requires sophisticated accounting systems. In addition, companies also deal with uncertainty about climate change policies that can change. This uncertainty makes it difficult for them to plan and implement effective strategies, as it is difficult to predict how regulations will develop in the future (Bui & de Villiers, 2017).

Amid these challenges, uncertainty around carbon emissions regulations can hamper the decision-making process, leading companies to wait until there is more clarity

before taking action (Kumarasiri & Gunasekarage, 2017). Additionally, collecting and analyzing data on climate risks can be complicated, especially when companies have to deal with incomplete or non-standardized data. This makes it difficult for them to get an accurate picture of the impact of climate on their operations (Carmela Gulluscio et.al., 2023).

Carbon Accounting and Emissions Management

International agreements such as the UNFCCC Paris Agreement and the SDGs establish accountability for carbon emissions and actions related to climate change. They require measuring and reporting emissions to meet targets, or at least to assess progress towards meeting them (Laine et al., 2017). The Global Reporting Initiative (GRI) is one of the most widely adopted sustainability reporting standards worldwide. GRI provides a framework for companies to report on their economic, environmental, and social impacts. In the context of climate change, GRI encourages companies to disclose information on greenhouse gas emissions, energy use, and mitigation strategies implemented to reduce environmental impacts. By following the GRI standards, companies can present comprehensive and transparent reports on their contributions to sustainability and climate change issues (Monasterolo, 2020).

In addition, there is the TCFD, established in January 2016 by a group of private sector experts under the G20, with the aim of developing a framework that companies around the world can use to consistently disclose climate-related information. The TCFD aims to help investors, lenders and insurance underwriters evaluate and price climate-related risks and opportunities (Nisanci, 2021).

The GHG Protocol is an international standard designed to provide consistent and transparent guidelines for measuring emissions, facilitating comparisons across companies and industry sectors (Omran & Yaaqbeh, 2023). The protocol consists of several components, including corporate accounting and reporting standards that serve as guidelines for companies to calculate and report their greenhouse gas (GHG) emissions. In addition, there are project quantification standards that provide guidance for measuring emission reductions from specific projects. The GHG Protocol also classifies emissions into three categories, namely scope 1, 2, and 3. 1) Direct emissions from sources owned or controlled by the company, such as emissions resulting from the combustion of fuel at the company's facilities. 2) Indirect emissions resulting from energy consumption, such as emissions generated by power plants that supply energy to the company. 3) Other indirect emissions that occur in the company's value chain, including emissions from suppliers and the use of products by consumers (Gillenwater, 2022).

Emission management as a systematic effort to control and reduce carbon dioxide (CO_2) emissions through the implementation of environmental taxes and related policies, in order to improve environmental conditions and support sustainability (Yin et al., 2022). Emission management, through systematic efforts to control and reduce carbon dioxide (CO_2) emissions through the implementation of environmental taxes and related policies, has a significant impact on current climate change. By reducing CO_2 emissions, these efforts help slow global warming and maintain the balance of ecosystems, while protecting vulnerable biodiversity. In addition, these policies encourage collective awareness in society and industry about the importance of climate change mitigation, and

stimulate innovation in clean technology and renewable energy. Emission management is not only important for environmental protection, but also as a crucial step in the global effort to address climate change and reduce the negative impact of greenhouse gases on the planet (Omodero et al., 2022).

Greenhouse gases (GHG) are gases that are trapped in the atmosphere and play a role in the global warming process by trapping heat from sunlight (Omodero et al., 2022). Among these gases, carbon dioxide (CO2) is the most significant, resulting from the burning of fossil fuels, deforestation, and industrial activities. In addition, methane (CH4) produced from agriculture and waste, and nitrous oxide (N2O) from agricultural practices, also contribute to the greenhouse effect. Fluorinated gases, although less common, also play a role in global warming (Eskander & Fankhauser, 2020).

Emissions Management and Carbon Reduction Initiatives

Companies are currently implementing various strategies to reduce greenhouse gas emissions, one of which is by switching to renewable energy, such as solar, wind, and biogas, which not only reduce dependence on fossil fuels but also significantly reduce carbon footprints. In addition, increasing energy efficiency through advanced technology and better operational practices is also a major focus, with companies trying to minimize energy consumption in production and distribution processes. Equally important, participation in carbon trading provides economic incentives for companies to reduce emissions, allowing them to buy or sell carbon credits in accordance with established emission reduction targets. Through this combination of strategies, companies not only contribute to climate change mitigation but also enhance their image as environmentally responsible entities, which in turn can attract consumers and investors who are increasingly aware of sustainability issues (Eskander & Fankhauser, 2020).

Renewable energy is defined as a source of energy derived from natural resources that can be naturally renewed and do not cause significant environmental impacts compared to conventional energy sources. Renewable energy includes technologies such as hydro, solar, wind, biogas, and others, which play an important role in mitigating and adapting to climate change, especially in countries that are vulnerable to climate change. Renewable energy not only contributes to reducing greenhouse gas emissions, but also improves the social, health, and economic well-being of communities by providing access to cleaner and more sustainable energy (Suman, 2021).

Carbon Trading is a market-based mechanism designed to reduce greenhouse gas emissions through the buying and selling of carbon units (Prihatiningtyas et al., 2023). Sistem ini memungkinkan perusahaan untuk membeli dan menjual izin emisi, creating a market for carbon emissions. The goal is to achieve overall emission reductions in an economical and efficient manner. The European Union ETS is one of the most developed and well-established emissions trading systems in the world (Naranjo Tuesta et al., 2021).

The Role of Accounting in Green Investment

Green investment refers to all forms of investment aimed at supporting projects that focus on environmental protection and sustainability (Zahan & Chuanmin, 2021). This includes investments in clean energy, green technologies, waste management, and efforts to reduce carbon emissions. This study examines how green investments can increase clean energy consumption and reduce CO2 emissions in China, showing that these investments have a positive impact on environmental quality. In accounting, it also supports what is called Green Finance and Green Bonds with each understanding Green

Finance refers to the flow of capital directed to support projects that have environmental benefits and Green Bonds are financial instruments issued to raise funds specifically for projects that have a positive impact on the environment (Prihatiningtyas et al., 2023a).

Accounting supports Green Finance and Green Bonds by providing transparency and accountability in reporting the use of funds for environmentally friendly projects. Through proper measurement and reporting, accounting can ensure that investments made actually have a positive impact on the environment and meet the criteria set for Green Bonds. The impact of accounting that supports Green Finance and green bonds on sustainable disclosure is increased transparency in a company's financial statements. This allows stakeholders to better understand the environmental impact of a company's activities and the use of the funds generated. In addition, better disclosure can encourage companies to be more responsible in their sustainability practices, increasing public and investor confidence in the company's environmental commitments (Prihatiningtyas et al., 2023a).

Impact of Climate Change on Financial Reporting

Since Mark Carney's 2015 speech at Lloyd's of London, climate-related financial risks have received increasing attention from academics and financial institutions. Carney warned that the misalignment between long-term climate impacts and short-term investment decisions could lead investors to overlook the economic risks of climate change. In 2016, the Bank of England published a report defining physical and transitional climate risks and the channels through which they could pose material risks to financial actors (Monasterolo, 2020). Here are some of the main ways in which climate risk can impact financial statements: 1) Physical risk: Climate change can cause extreme weather events, such as floods, droughts, and storms, which can damage a company's physical assets. This damage can result in significant repair costs and reduce the value of assets, which in turn can impact a company's financial statements. 2) Transition risk: Companies that do not adapt to changing climate policies or the transition to a low-carbon economy may face financial risks. For example, if companies do not invest in cleaner technologies, they may experience a decline in share value or an increase in the cost of capital. This can be reflected in their financial statements through decreased revenues or increased costs (Battiston, Dafermos, et al., 2021).

Gaps in Literature and Recommendations

There is variation in environmental reporting standards across countries, making it difficult to compare environmental performance across companies and countries. This creates challenges regarding the consistency and transparency of the reports produced (Omran & Yaaqbeh, 2023). Developed and developing countries often apply different methodologies in reporting their contributions to climate finance. As a result, this creates confusion and makes it difficult to compare data between countries (Weikmans & Roberts, 2019). There is a need to develop more harmonised reporting standards to increase transparency and accountability in companies' disclosure of environmental risks (Nieto, 2019). In addition, many companies face challenges in collecting the information needed for accurate reporting. These limitations are often caused by lack of resources, difficulties in measuring performance, and inconsistencies in reporting practices. As a result, the level of sustainability reporting in many countries is low. To address these

issues, it is important for countries and companies to adopt more consistent methodologies and improve data collection capabilities (Shad et al., 2019).

Recommendations for future research involve further efforts to address these gaps, including the development of more detailed global regulatory policies. It is hoped that this will provide a better framework for companies to manage climate change-related risks and report their environmental impacts in a more transparent and accountable manner (Bui & de Villiers, 2017). One step that can be taken is to develop internationally recognized reporting standards, such as those carried out by the ISSB (International Sustainability Standards Board) (Omran & Yaaqbeh, 2023).

Conclusion

Both carbon accounting and environmental accounting have an important role to play in addressing climate change, but their effectiveness depends on the objectives and context. If the primary objective is to directly reduce GHG emissions, carbon accounting may be more effective. However, for a more holistic and sustainable strategy, environmental accounting can provide deeper insights. Combining the two approaches can also be a very effective strategy. CO2 emissions have a significant negative impact on the environment, and there is increasing pressure from regulators, customers and the public to reduce total emissions. Therefore, companies need to adopt more sustainable strategies, such as switching to renewable energy and increasing energy efficiency, to reduce their carbon footprint. Participation in carbon trading also provides economic incentives for companies to reduce emissions, which in turn can improve their image as environmentally responsible entities.

However, challenges in environmental reporting remain, mainly due to differences in reporting standards across countries. This makes it difficult to compare environmental performance between companies and countries, and reduces the consistency and transparency of the reports produced. Therefore, there is a need to develop more harmonized and consistent reporting standards to improve transparency and accountability in companies' disclosure of environmental risks. In addition, many companies have difficulty in collecting the information needed for accurate reporting, often due to resource constraints and inconsistencies in reporting practices. This results in low levels of sustainability reporting in many countries. To address this issue, it is important for countries to collaborate in developing policies and regulations that support better emissions management and reporting.

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